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(54) **Method and apparatus for improving the operational characteristics of a vehicle.**

(57) A method and apparatus for improving the operation of a vehicle (10) detects unevennesses of the road on which the vehicle is moving by sensing oscillations at two positions (24,26) of the vehicle arranged in spaced relationship behind each other in the direction of movement of the vehicle. The actual speed of the vehicle is determined by correlating the oscillations sensed and by multiplying the time the delay therebetween with the distance (D) of the two positions. The slippage of the wheels (16,18) which is an important parameter in particular for braking the vehicle, may be calculated by setting the determined actual speed into relation to the speed of the vehicle as derived from the rotary speed of the wheels. The vehicle may be controlled independence of this slipage and other parameters derived from the actual speed, the slippage and forces vertically acting onto the wheels of the vehicle.

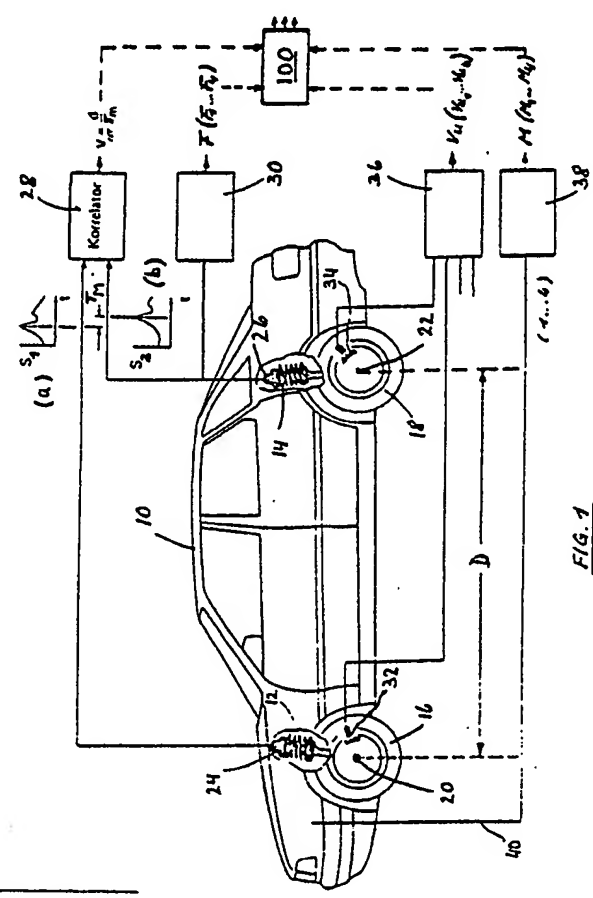

FIG. 1

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METHOD AND APPARATUS FOR IMPROVING THE OPERATIONAL CHARACTERISTICS OF A VEHICLE

Technical Field:

The invention relates to a method and an apparatus for improving the operational characteristics of a vehicle, in particular an automobile by determining the actual speed of the vehicle and the rotational speed of its wheels and using any differences therebetween for controlling the operation of the vehicle.

Background Art:

Usually, the speed of a vehicle is derived from the rotational speed of a wheel therof. However, due to the slippage of the wheels such speed measurement is rather inexact, in particular during braking of the vehicle. Now, automatic braking systems have been introduced in the recent years. These systems are based on the behaviour of the wheels which might be quite different from that of the movement of the vehicle when there is a remarkable slippage.

The DE-A2- 34 35 866 discloses a method for determining the actual speed of a vehicle. In order to avoid any influence of the slippage between the wheels of the vehicle and the road it is proposed to pick-up the oscillations of the wheels caused by the road unevenness and to determine the actual absolute speed of the vehicle by evaluating the time difference of the oscillations of the front and rear wheels.

The DE-A2- 27 51 012 discloses an apparatus for determining the speed of a vehicle by means of two transducers arranged in a fixed distance in the direction of movement of the vehicle. The transducers generate electrical signals reflecting unevennesses of the road surface. The signals of the two transducers are correlated with each other for determining the time delay therebetween which is multiplied by the fixed distance in order to determine the actual speed. The vehicle is further provided with a measuring device for determining the distance covered by the vehicle. This device is operated by the rotation of the wheel. The reading of the distance measuring device is corrected by the integrated signal of the determined actual speed.

The DE-A2- 28 49 028 discloses a similar device for determining the actual speed of a vehicle by cross-correlating signals derived from sensors arranged at a pre-determined distance in the direction of movement of the vehicle. Specifically, mechanical -to-electrical transducers are used formed by strain gauges, force or acceleration pick-up devices provided at the wheel suspensions, the springs or shock-absorbers or bumpers of the vehicle.

Summary of the Invention:

It is an object of the instant invention to provide a method and an apparatus for optimizing the operation of a vehicle.

It is a further object of the present invention to provide a method and an apparatus for improving the operation of a vehicle in extreme situations as the braking of the vehicle.

These and other objects of the instant invention are achieved by a method for improving the operational characteristics of a vehicle provided with wheels arranged behind each other in a moving direction of the vehicle comprising the steps:
determining a first speed of movement of the vehicle dependent on the rotary speed of at least one of said wheels;
sensing first oscillations at a first position of said vehicle, caused by said vehicle passing over unevennesses of a road during movement;
sensing second oscillations at a second position of said vehicle located at a fixed distance behind said first position in said moving direction, caused by said unevennesses of said road;
correlating said first and second oscillations for determining a time delay therebetween;
calculating a second speed of the movement of said vehicle from said fixed distance between said first and second positions and said fixed distance between said first and second positions and said time delay; and
setting said first and second speeds into relation to each other.

According to another aspect of the invention an apparatus for improving the operational characteristics of a vehicle provided with wheels arranged in a fixedly spaced relationship to each other in a direction of movement of said vehicle comprises:
means for determining a first speed of movement of the vehicle in dependence on the rotary speed of at least one of said wheels;
means for sensing first oscillations at a first position of said vehicle, caused by said vehicle passing unevennesses of a road during movement;
means for sensing second oscillations and a second position of said vehicle located at a first distance behind said first position in said moving direction, caused by said unevennesses of said road;

means for correlating said first and second oscillations for determining a time delay therebetween;
means for calculating a second speed of the movement of said vehicle from said fixed distance between said first and second positions and said time delay; and
means for setting said first and second speeds into relation to each other.

Brief Description of the Drawings:

Fig.1 is a schematic view of an apparatus according to the invention as used in connection with a motor car; and

Fig.2 is a sectional view of an exemplary arrangement of a force sensor included in a motor car wheel suspension.

Description of a Preferred Embodiment of the Invention:

According to Fig. 1 a motor car 10 of the embodiment is provided with front spring legs 12 (left and right) and rear spring legs 14 for suspension by means of a front wheel axle 20 and a rear wheel axle 22 of the front wheels 16 and the rear wheels 18, respectively. The spring legs 12, 14 support via force measuring devices 24 and 26, respectively, on the body of the motor car as indicated in more detail in Fig. 2.

Further details of the arrangement of a spring leg having integrated a force measuring device as used with the embodiment have been disclosed in the International Patent Application Publication WO/87/02129 (United States Patent Application, Serial No. 057,892 of May 22, 1987)which in its entirety is made contents of the instant patent application. The force measuring device used has the particular advantage that any lateral forces are eliminated and that signals are produced representing the exact value of the forces exerted onto the wheel. As well-known in the art, these signals are processed in an evaluating device 30 in connection with a board computer 100 for various purposes for instance for adjusting the spring characteristic of the spring legs 12, 14 in dependence on the load put into the motor car.

Now, these force measuring devices 22, 26 are used for determining the actual car speed, in that they pick-up oscillations caused by any unevennesses of the road which oscillations are illustrated in simplified manner in the diagrams (a) und (b). The oscillations S_2 caused by the rear wheel 18 are time-delayed by the time T_M in respect of the oscillations S_1 of the front wheel 16. The oscillations S_1 and S_2 are illustrated very simplified only. In reality, these oscillations are rather irregular excursions which are applied to a correlator 28 to be correlated in well-known manner in order to determine the delay T_M. Considering a fixed distance D between the front and rear axles 20, 22 the actual speed may be determined very accurately.

With the preferred embodiment of the invention force measuring devices 24, 26 are used as disclosed in the above mentioned International Patent Application WO 87/02129. However, other types of force measuring devices as piezo-electric force sensors may be used as well. Due to the high processing speeds of a board computer, the momentary actual speed is immediatedly available as an exact value and may be compared with the rotary speed of one of the wheels as derived in well known manner via a pulse generator or the like. The result of this comparison is a measure for the slippage between the wheels and the road, which in turn is a characteristic value indicating prior to a brake operation, i.e. in the acceleration or rolling phase of a car, changes in the road characteristics, for instance icy places. This parameter may then by used for an automatic control of the actual speed or for indicating a critical situation to the driver.

Fig. 1 shows usual sensors 32, 34 provided at the wheels 16, 18 for determining the actual rotary speed V_U (V_{U1},...V_{U4}) of the wheels as they are used in a well-known manner in automatic braking systems. Up to now, this rotary speed of the wheels has been used solely for determining the speed of the motor car with the consequence that in particular with difficult road situations a considerable slippage has falsified the actual speed value of the car. Fig. 1 shows a unit 36 used for generating a mean or average speed V_U on the basis of the rotary speeds of the four wheels.

Now, by comparing the mean rotary speed V_U with the determined actual speed V_{ACT} the actual slippage of the wheels 16, 18 on the road may be determined. Alternatively, the individual rotary speeds V_{U1} ..., V_{U4} may be compared with the actual speed V_{ACT} and the slippage of each wheel may be determined individually.

For an optimized starting and braking of a motor car it is essential that the actual slippage does not exceed a pre-determined value, for instance 5%; otherwise, the static friction changes to a sliding friction with the result of a suddenly and considerably reduced friction number.

Therefore, with the actual slippage exactly determined as explained above the torque of the motor or the brake pressure, respectively, may be controlled such that that the static friction number is maintained and that there is no change to a sliding friction. It is essential that changes in slippage due to a change in road condition are recog-

nized before braking.

For a still further improved automatic control of the operation of the motor car in addition to the forces F_1 to F_4 excerted onto the wheels by means of the force measuring devices 24, 26 the individual moments M_1 to M_4 acting on the individual wheels 16, 18 may be determined by a well-known unit 38. Averaging moments M_1 to M_4 results in a mean or average moment M which enables the calculation of the frictional force F_F and, in particular the static frictional force F_{Fs} as long as there is no remarkable slippage. In consideration of the individual forces F_1 to F_4 acting on the wheels the static friction number Rs may be calculated which is valid until a pre-determined slippage is exceeded. The driving moment or torque of the motor or the brake moment, respectively, acting on the car wheels are then controlled such that the condition of the static friction is maintained. Furthermore, it is now possible to adjust the actual car speed by means on these values in order to maintain a pre-determined braking distance.

With a further improvement of the method and the apparatus of the invention the motor car may be provided with a distance measuring apparatus acting in driving direction, for instance a radar device. In addition to the parameters as determined according to the above explanations the momentary distance from another car driving in front or from a fixed object may be determined and used to control the car speed by acceleration or braking.

Furthermore, by means of the board computer 100 with the actual speed as determined according to the above description the speed of the car may be adjusted to a set fixed value. The friction number R determined from the accelerating or braking moment M and the wheel force F may generally be used for indicating the condition of the road by comparing the determined friction number with stored values and using this comparison for appropriate controls and indications.

Fig. 2 shows an embodiment of a wheels suspension in more detail. The force measuring devices 24, 26 of Fig. 1 are represented by at least one pressure sensor 221 arranged between the spring leg 12 or 14, respectively, and a car body 200 such that the pressure sensor 221 operates as a wheel load sensor.

Specifically, the pressure sensor 221 is embedded in elastomeric material 223 in a widened annular space 238 between concentric cylindrical housings 222 and 237. The housing 237 is integral to an outer wall 224 of a spring leg bearing 203 receiving the spring leg 12 or, respectively, a piston rod 257 in bearing 227 in a pivotal manner. A spring 229 of the spring leg 12 supports on a spring disk 228. The housing 222 is integral to a flange 213 fixed by means of screws 226 to the car body 200.

It is of particular advantage that the force measuring devices provided in the suspension of the spring legs according to Fig.2 are used both for sensing the oscillations for measuring the actual speed and for determining the wheel force F. Thus, these force measuring devices have a double function. Futhermore, these force measuring devices may be used for picking-up accelerations, as longitudinal and lateral accelerations giving an information in respect of the response of the car, in particular its inclination when bending-off.

A continuous measurement of the values explained before enables a considerable improvement of the operation of vehicles.

By the way, from the degree of correlation of the oscillations S_1 and S_2 conclusions are possible in respect to the inclination of the vehicle. Therefore, an oversteering or understeering may be determined and corrected.

With the embodiment as explained above the moments M_1 to M_4 of the individual wheels are determined. As far as these wheels are synchronized such that the same moment acts on them the driving torque derived from the motor may be used as a parameter as indicated with line 40 in Fig. 1.

With the preferred embodiment the detection of the oscillations is made by force measuring devices. Alternatively, acceleration measuring devices may be used.

As regards the evaluation of the picked-up oscillations various known methods may be used as analog methods using integration or digital methods using sampling of the oscillations followed by a digital processing.

Since the momentary actual speed may be determined very accurately by integrating over the driving time of the vehicle the exact driving distance may be determined.

Though the preferred embodiment relates to a usual motor car the invention is equally applicable for trucks, track-bound vehicles and any other type of vehicle including motor cycles. It may even be used for airplanes as far as the latter are provided with wheels aligned and spaced in moving direction.

From the above description it may be gathered that the method and apparatus according to the invention results in a considerable and suprising advantage with the operation of vehicles in particular motor cars. In particular, an automatic control of the operation of the vehicle is now possible using parameters as determined according to the invention or derived therefrom in a very accurate manner.

The invention as been explained, by way of example in such a manner that the individual parameters are determined step by step. However, a

skilled person will appreciate that by means of a suitable computer program determining of intermediate values may be skipped or that the processing may be accomplished in parallel.

Claims

1. A method for improving the operational characteristics of a vehicle provided with wheels arranged behind each other in a moving direction of the vehicle comprising the steps:
determining a first speed of movement of the vehicle dependent on the rotary speed of at least one of said wheels;
sensing first oscillations at a first position of said vehicle, caused by said vehicle passing over unevennesses of a road during movement;
sensing second oscillations at a second position of said vehicle located at a fixed distance behind said first position in said moving direction, caused by said unevennesses of said road;
correlating said first and second oscillations for determining a time delay therebetween;
calculating a second speed of the movement of said vehicle from said fixed distance between said first and second positions and said time delay; and
setting said first and second speeds into relation to each other.

2. The method of claim 1 further comprising the step:
determining a slippage of said wheel from said relation between said first and second speeds of said vehicle.

3. The method of claim 2 further comprising the steps:
measuring the momentary force vertically acting on at least one wheel; and
setting said force into relation to said slippage.

4. The method of claim 3 further comprising the steps:
determining a driving moment acting on at least one of said wheels; and
setting said driving moment into relation to said slippage in dependence on the said force acting on said wheel in order to determine a momentary friction number between said wheel and said road.

5. The method of claim 4 further comprising the step:
controlling a momentary speed of movement of said vehicle in dependence on said slippage and said friction number effective between said wheels and said road.

6. The method of claim 4 or 5 further comprising the step:
measuring a momentary distance of said vehicle from an object in front of said vehicle for controlling said actual speed in dependence on said slippage and said friction number.

7. The method of any of the claims I to 6 wherein an inclination of said vehicle is determined in dependence on a degree of said correlation between said first and second oscillations of said individual wheels.

8. The method any of the claims I to 7 wherein individual values in respect of said first and second speeds, an acceleration or deceleration and said force vertically acting on said wheels, of said individual wheels are set into relation to each other and evaluated in common.

9. A system for improving the operational characteristics of a vehicle provided with wheels (16,18) arranged in a fixedly spaced relationship (D) to each other in a direction of movement of said vehicle comprising:
means (32,34,36,38) for determining a first speed of movement of the vehicle in dependence on the rotary speed of at least one of said wheels;
means (24) for sensing first oscillations at a first position of said vehicle, caused by said vehicle passing unevennesses of a road during movement;
means (26) for sensing second oscillations and a second position of said vehicle located at a first distance (D) behind said first position in said moving direction, caused by said unevennesses of said road;
means (28) for correlating said first and second oscillations for determining a time delay therebetween;
means (100) for calculating a second speed of the movement of said vehicle from said fixed distance between said first and second positions and said time delay; and
means (100) for setting said first and second speeds into relation to each other.

10. The system of claim 9 further comprising:
means (100) for determining a slippage of said at least one wheel (16,18) from the relation between said first and second speeds of the vehicle;
means (24,26,30) for measuring the momentary force vertically acting on at least one wheel; and
means (100) for setting said force into relation to said slippage.

11. The system of claim 10, further comprising:
means (100) for determining a driving moment acting on at least one of said wheels(16,18) ; and
means (100) for setting said driving moment into relation to said slippage in dependence on the said force acting on said wheel in order to determine a momentary friction number between said wheel and said road;
means (100) for controlling a momentary speed of movement of said vehicle in dependence on said slippage and said friction number effective between

said wheel and said road; and/or
means (100) for measuring a momentary distance of said vehicle from an object in front of said vehicle for controlling said actual speed in dependence on said slippage and said friction number.

12. The system of claim 9,10 or 11 further comprising:
means (24,26,28,100) for determining an inclination of said vehicle in dependence on a degree of said correlation between said first and second oscillations of said individual wheels.

13. The system of any of the claims 9 to 12 further comprising:
means (100) for setting individual values in respect of said first and second speeds, an acceleration or deceleration and said force vertically acting on said wheels, of said individual wheels into relation to each other and for evaluating them in common.

14. System of any of the claims 9 to 13 wherein said means for sensing said first and second oscillations are force measuring devices (221) integrated in spring legs (Fig.2) of said vehicle.

15. System of claim 14 wherein said spring legs (Fig.2) comprise two concentric housings (222,237) forming a cylindrical gap therebetween a complementary step each being provided at a interior peripheral surface of said outer housing (237) and said outer peripheral surface of said inner housing (222) forming a space therebetween, said space and said gap being filled with elastomeric material (223) and said force measuring devices being arranged in said space embedded in said elastomeric material.

16. A system of improving the operation of a vehicle provided with wheels comprising:
means for determining a momentary force acting on said wheels;
means for determining a momentary acceleration/deceleration force acting on said vehicle;and
means for setting determined resulting values into relation to each other.

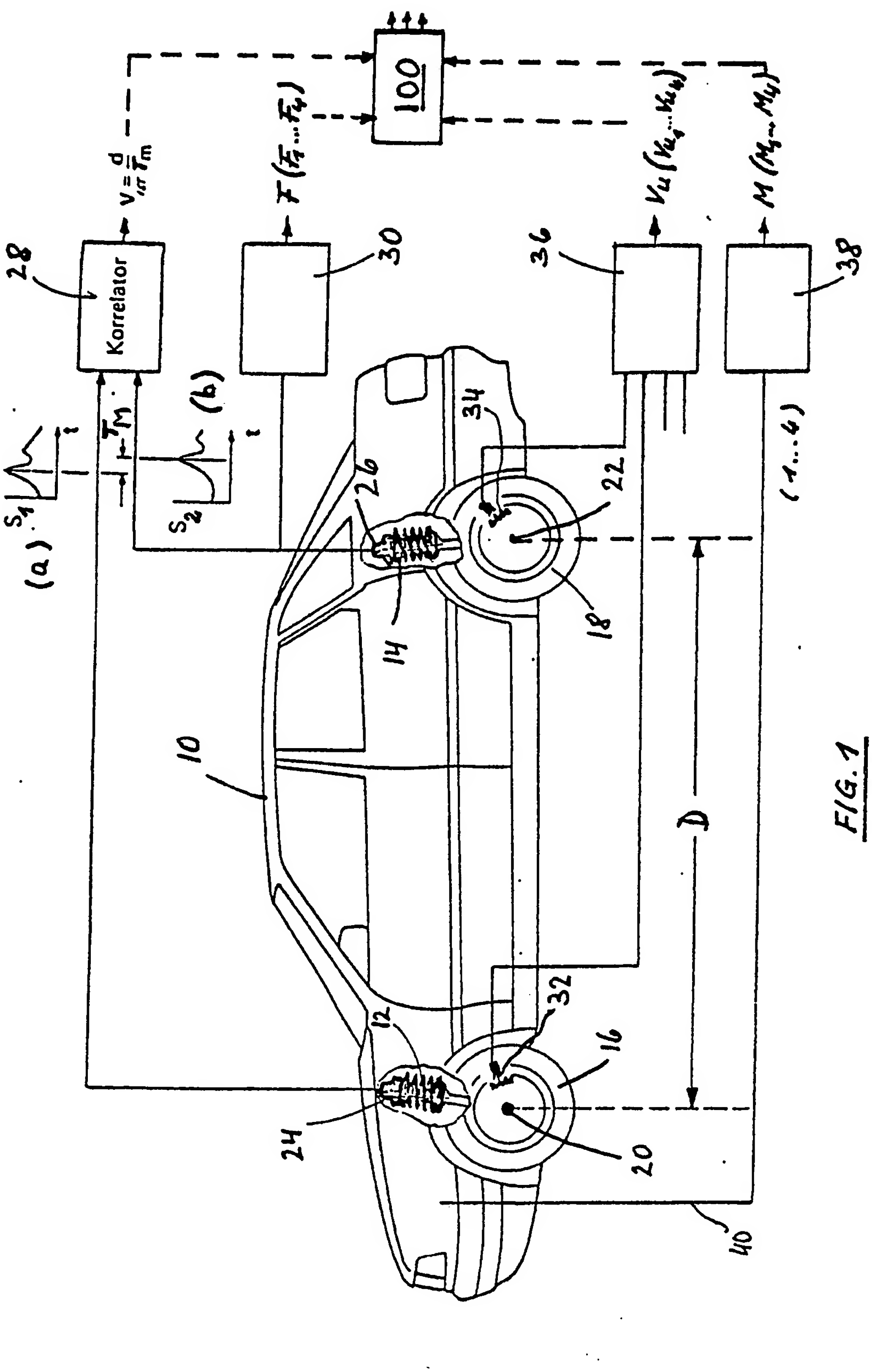
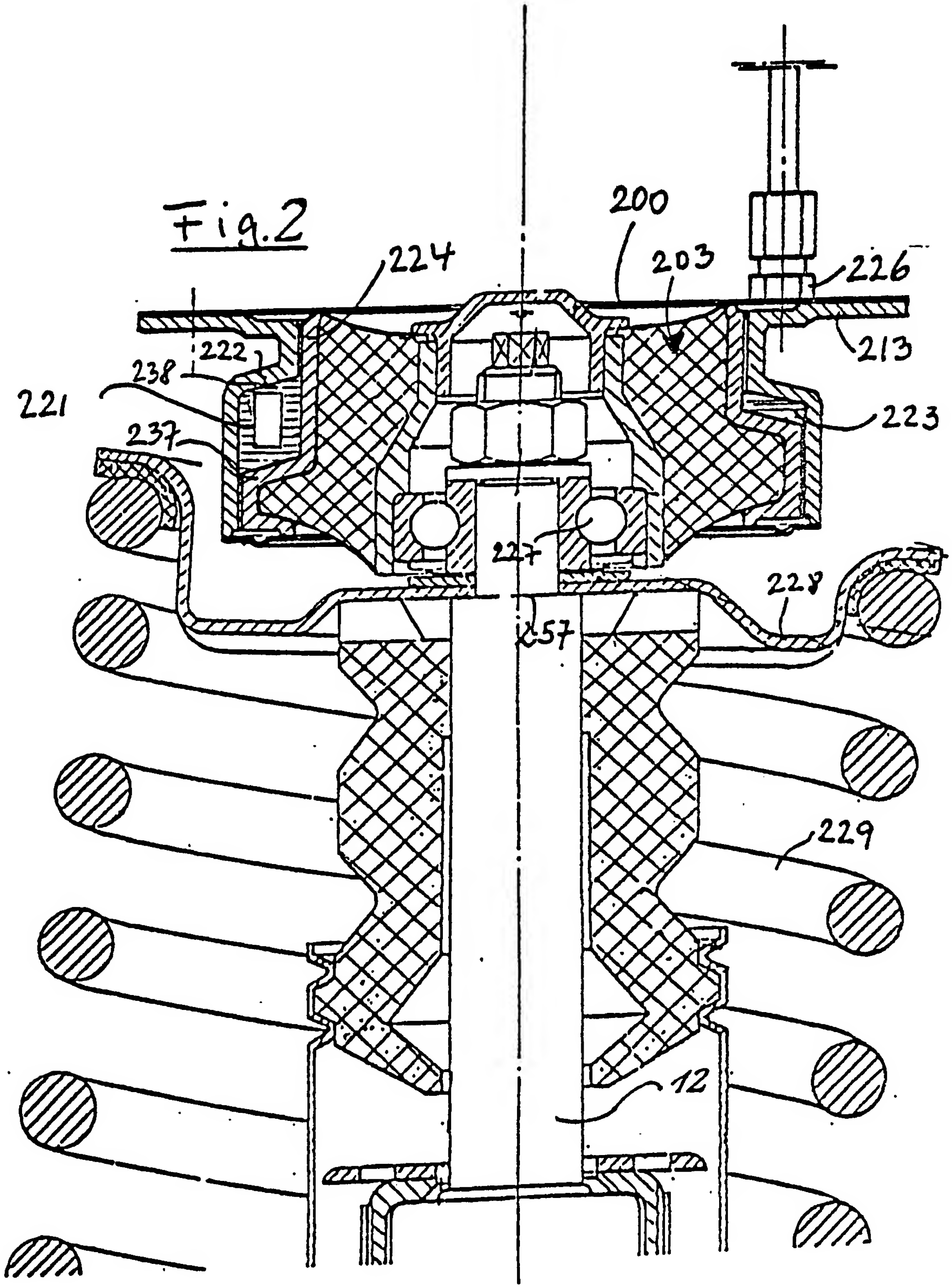


FIG. 1

Fig. 2



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(54) Method and apparatus for improving the operational characteristics of a vehicle.

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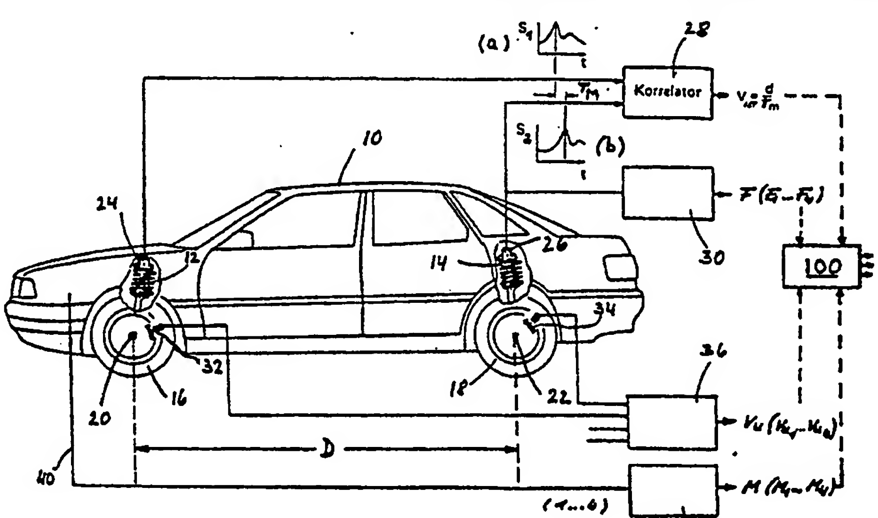

FIG. 1

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EUROPEAN SEARCH REPORT

Application Number

EP 88 10 9199

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X,D	DE-A-2751012 (ESG ELEEKTRONIK-SYSTEM-GESELLSCHAFT MBH) * page 2, paragraph 1 *	1, 2, 9	G01P3/66 B60T8/66
Y,D	* page 3, paragraph 4 * * page 4, paragraph 3 * * page 5, paragraph 5 - page 8, paragraph 1; figures 1, 2 *	3-5, 8, 10, 13, 16	
Y	GB-A-2061435 (NISSAN MOTOR COMPANY LIMITED) * page 1, lines 5 - 13 * * page 1, lines 52 - 80 * * page 2, lines 10 - 39 * * page 3, lines 61 - 90 * * page 4, lines 5 - 14 * * page 4, lines 26 - 36 * * page 4, lines 84 - 102; figures 1, 2 *	3-5, 10, 16	
Y	GB-A-2169675 (ALFRED TEVES GMBH) * page 2, line 99 - page 3, line 64 * * page 4, lines 59 - 76; figure 1 *	8, 13	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
A,D	WO-A-8702129 (PFISTER) * page 9, last paragraph - page 10, paragraph 1; figure 3 *	14, 15	G01P B60T

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 OCTOBER 1990	ROBINSON M.A.

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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